Assessing the use of Immersive Environments for Preparing Teachers to Address Challenging Student Behaviors

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Abstract

We do not think enough about how challenging behavior from students can affect teachers. Classrooms can be high-risk environments where actions and reactions can have severe consequences. Students' behaviors are a socio-emotional response, and a teacher's reaction to challenging behavior can directly affect the emotional state of a student. When faced with behavior challenges from students, not only must the teachers ensure that the situation is controlled to ensure safety but also ensure that teaching and learning outcomes are achieved. In teacher preparation, the typical approach to preparing teachers is to place the teacher candidate with an experienced teacher for a supervised professional practicum. During these practical experiences, the novice teacher candidate has direct interactions with and responsibilities for students. What if teachers had a chance to practice what to say to a student displaying challenging behavior in a safe environment that has no real risks or consequences, before they enter a real classroom?

The study compares the cognitive state of participants when exposed to three different methods of training: a traditional method – live role-playing, training in virtual reality and training using a tablet, and the cognitive state of participants between two consecutive exposures in each condition. In the tablet and virtual reality scenarios, teachers will be exposed to a 360-degree video of challenging behavior from a student.

In this thesis, we address the question of whether training in virtual reality affects the cognitive state of teachers as much as training using live role-play does. To help answer this, we recorded physiological data of participants (heartrate, voice and brainwaves) in all three conditions, and asked participants to fill out a stress-state questionnaire. We found no statistically significant differences in the results between the three conditions, providing support for the premise that virtual reality yields the same levels of emotional arousal as live role-play, and is hence a good alternative to live role-play.

Acknowledgement

I would like to thank my senior supervisor, Prof. Rob Lindeman, co-supervisor, Dr. Sungchul Jung and associate supervisor, Associate Prof. Misty Sato, for their timely advice and support. I am immensely grateful to Hamish Allan-Caney, Co-founder of Supporting Behavior 360 (SB360) for this collaboration, his guidance and insights. Finally I would like to thank my family and friends for their constant love and encouragement.

Contents

Chapter 1

Introduction

Challenging student behavior can have severe effects on the emotional state and experience of both students and teachers. It can hinder the achievement of learning goals and diminish the overall efficacy of learning for everyone in the classroom (Brouwers & Tomic, 1999; Emmer & Stough, 2001).

"Challenging behavior" generally refers to the "difficult" or "problem" behaviors which may be shown by children or adults with a learning disability (McGill, 2012). Aggressive behavior such as hitting, kicking and biting, destructive behavior such as ripping clothes, breaking windows, throwing objects and behaviors that cause self-injury such as head banging, self-biting and skin picking are all classified as challenging behaviors. It can also include tantrums and other behaviors (e.g., running away, eating inedible objects, rocking or other stereotyped movements) that inhibit a teaching and learning relationship or put the student in potential harm. Challenging behavior can put the safety of the person or others around them in some jeopardy. It can also have a significant impact on the person's or other people's quality of life (McGill, 2012). According to the Child Mind Institute (Rappaport & Minahan, 2019), in a typical classroom of 20, chances are good that one or two students are dealing with serious psycho-social stressors relating to poverty, domestic violence, abuse and neglect, trauma, or a psychiatric disorder, and this number is only increasing.

Many pre-service teachers feel that their training in classroom management is not enough (Giallo & Little, 2003), and often feel unprepared when they enter real classrooms (Newly Graduated Teachers: Preparation and Confidence to Teach, 2017). Classrooms are high-risk environments where actions and reactions have severe consequences. Despite that, we do not think enough about how challenging behavior from students can affect teachers. In research conducted by Berry et al., (2011) the results indicated that one third of the teachers who were surveyed felt inadequately prepared to teach, noting that one of the greatest needs in professional development is issues related to challenging behaviors (Hudson, Voytecki, Owens & Zhang, 2019). Teacher preparation programs offer courses in positive classroom management practices. Unfortunately, many pre-service teachers graduate before they can become fluent in classroom management skills (Hudson et al., 2019). There are many possibilities for this: (a) lack of safe and controlled environments for practicing classroom management skills, (b) limited scope for implementing a classroom management strategy that was learnt, (c) the range of conditions which emphasize on the need for classroom management, and (d) the challenge in replicating or interrupting certain situations to have a teachable moment (Hudson, et al., 2019). As a result, many pre-service teachers are not adequately prepared to address challenging behavior in the classroom (Dieker, Hynes, Hughes & Smith, 2008; Jones & Chronis-Tuscano, 2008). There is also a lack of training related to managing students with special learning needs. Teachers who teach in schools that are specifically meant for students with intellectual disabilities have prior training. However, when it comes to teachers who teach in mainstream schools where challenging behavior from students can sometimes be expected, there is limited specialized training available. In a focus group interview with in-service high school teachers, participants reported the need for more training related to dealing with students with special learning needs, students with disorders (vision, hearing and speech disorders), behavior management issues, classroom diversity, individualized learning and classroom management (Stavroulia et al., 2017). This is important because disability may not be something a person is born with; it could also be a result of a traumatizing life incident, effects of which are not often recognized every day.

A "one size fits all" approach to instruction in classrooms is no longer a viable practice today. Accommodating the diversity of academic needs is important to the development of the student. As the education system is beginning to recognize the uniqueness of the individual child, it requires teacher education to develop new ways of preparing teachers who can be responsive and supportive. Thus, the preparation of pre-service teachers for this complex task becomes an even greater challenge as novices are assisted in learning to think, know, feel, and act like a teacher capable of navigating this complexity (Feiman-Nemser, 2008).

Traditional methods of training such as lectures have been replaced by more effective methods (Hogan et al., 2015). Some student-teachers find it hard to maintain concentration during lectures because they find it too boring (Struyven, et al., 2010). Pre-service teachers are not adequately prepared for today's challenges because most teacher education programs are still very theoretical and disconnected from real school environments

(Darling-Hammong et al., 2005). When teachers start teaching in real classrooms, they start using trial-and-error techniques that could have a negative effect on the cognitive, social and psychological development of the students (Chiero and Beare, 2010; Darling-Hammond, 2006). Gaining real-world experience for pre-service teachers is often not possible because access to schools and students is difficult. Hence, the need to address the theory-practice gap, so that teachers are also provided with high-quality practical skills required for supporting high-quality education (Stavroulia et al., 2019), can be approached using new technologies which we address in this thesis.

A common method of practicing classroom management in teacher preparation is through live role-playing which is interactive and involving. Academic live role-playing (not the same as role-playing games) can be defined as the involvement of participants and observers in a real problem situation along with the desire for resolution and understanding that this involvement engenders (Joyce, Weil & Calhoun, 2009). However, live role-playing has its own constraints. The biggest disadvantage of role-play is the participants' cognition. There may be two extremes to this – either teachers may like role play as it can be seen as an opportunity to "enjoy the limelight" or they may hate it as it can lead to a sense of feeling judged by their peers for their performance. If the latter is the case, it can lead to anxiety which could potentially impair learning from earlier in the day. If participants cannot relate to the situation or if they perceive it as inauthentic, this can have an impact on any benefits from skills practice. The other disadvantage is that role-play is limited by space – it requires a special setting for the action to be performed. This can be difficult for people who may struggle to visualize different contexts; in other words, there is very little mental involvement. Role-play is also limited by people. The number of people available to "act" in the different roles always must be taken into consideration. It also requires an expert's guidance and leadership. Often, the purpose of role-playing may be defeated when participants start having too much fun in the process. Participants must imagine that other performers in the role play are authentic characters. However, when it is an adult role-playing as a student, it may feel unrealistic. Although role-playing has been an effective training method in many ways, the ongoing pedagogy being developed to work inside the theory-practice gap might integrate emerging technologies and ways that provide real-world scenarios to be part of the teacher education curriculum.

Virtual reality (VR) offers many features that address some of the limitations of live role-playing as a means of teacher education. VR can replicate realistic situations, and the necessary headsets have come down in price. VR can be used to more precisely design what we want and what we think is effective for teacher education. We can also implement changes when needed because it is not as people-dependent as role-playing. With VR, it is only the user in the virtual world unlike in role-play where there are at least two persons involved, each of whose actions may affect the other.

VR has not been explored as much as role-playing in teacher training. The motivation behind this study emerged from this. We wanted to compare the cognitive state of teachers when they role-play a challenging student-teacher scenario, to a similar scenario in VR and in tablet form.

Due to the lack of research done in using VR in teacher training education methods, we want to draw implications from the data, and see if there are any visible patterns that we notice. These patterns could lead to new pedagogical approaches in teacher education that better prepare teachers for the complexity of supporting individual learners.

1.1 Research questions

This thesis will investigate the following research questions:

- Research question 1: Does VR training impact the physiological state of a teacher when experiencing challenging behavior from a student in the same way as training using live Role-play?

  We collected physiological data from participants across all three conditions, and compared them. The measurements we used were voice, brainwaves, heartrate, and a stress-state questionnaire. If the physiological signals between the live Role-play method of training and training using tablet and VR technology are similar, we could conclude that VR and tablet could be good alternatives to live Role-play.

- Research question 2: Is VR as engaging as Role-playing for teacher-training?

  VR has proven to provide a much more realistic and immersive experience as compared to exposure to the same video in a 2D (tablet) screen (Ding, Zhou, & Fung, 2018). This research explores if VR, as a technology tool, is as engaging as a live Role-play. For this, we administered a presence questionnaire that helped us understand whether participants feel like they are really interacting with the person in the VR condition. The stress-state questionnaire also gives us engagement scores which we are using to compare between the three conditions.

- Research question 3: Is there a significant difference in the physiological state of the participant between first and second exposure?

In this study, we exposed the participant to the same situation, twice, with a ten-minute interval between first and second exposures. The reason behind this is because we wanted to know if the second exposure caused lower stress levels indicated by lower heartrate, higher heartrate variability, and lower distress and worry scores.

1.2 Hypotheses

H1 Engagement level is higher in VR as compared to Tablet and live Role-play.

We expect higher level of engagement in immersive environments. Live Role-play, while immersive, is not expected to perform as well because the actor scenario will feel less authentic than the video which uses a real student in a real classroom environment.

H2 The physiological data show more emotional arousal during the first exposure than the second exposure.

We anticipate that novel effects of the treatment will be diminished in a repeated administration of the treatment.

H3 The arousal levels are higher in VR than in live Role-play and Tablet.

We expect that exposure to VR simulates higher arousal levels than live Role-play and Tablet because the participant will be surrounded by the virtual environment, and exposed to challenging behavior from a real student.

Heartrate, mean pitch of the voice and brain waves were recorded during the experiments. Additionally, participants were asked to fill a questionnaire which gave us the state of mind of the participant before and after the exposure. We recorded physiological signals in all conditions to see if we got similar data for live Role-play, VR, and Tablet, to conclude whether training using technology is a good alternative to live Role-play.

Physiological data were recorded in all three conditions and compared to assess whether VR and Tablet elicit similar levels of emotional responses as live Role-play. In VR, a presence questionnaire was also used which gave the participants' sense of presence.

Chapter 2

Literature Review

This chapter explores the relevant work associated with teacher-training using virtual reality, the usage of 360-degree videos and other immersive technologies in teacher education, and the importance of language used in classrooms to de-escalate student behaviors.

2.1 Technology used in teacher training

Technology has been a good supporting tool in helping teachers understand classroom management. Videos are common tools used to set the context for pre-service teachers, and they help capture teaching episodes that can be used to learn and improve. However, the major limitation is that videos provide only single-view perspective of a classroom.

By using 360-degree videos, it is possible for viewers to experience the full location and to engage further with the material presented. Dragging the 360-degree video up, down, left and right provides users with an interactive experience where the user gets to decide where they look and when. Reyna (2018) stated that 360-degree videos offer a unique sense of presence and immersion that is not possible to achieve using traditional videos. This immersion is due to viewers connecting with the content in a meaningful and emotional way (Reyna, 2018).

One way that the gap between theory and practice can be bridged is through experiential learning. Virtual reality (VR) could offer an effective way for this type of learning by providing engaging and immersive experiences that reflect real-world classroom situations (Caena, 2014). Virtual environments (VEs) can be designed to mimic real-life tasks and conditions. VR can put teachers in contexts, allowing for a seamless transition from the virtual world to "the real world." When teachers are exposed to a VE multiple times and practice handling challenging behavior, it may help them in terms of muscle memory when they enter that pedagogical moment.

The development of "extreme" scenarios can allow teachers to be trained via simulated stressful conditions that would be difficult to simulate using traditional teacher education methodologies in a real classroom setting. Equally important is the fact that constant technological advancements make VR technology more and more immersive. It provides a new level of experience to the users, making the simulated world seem like a real world, allowing the users to completely immerse themselves in the virtual world (Stravroulia et al., 2019).

2.2 Effect of language

De-escalation skill is the ability to redirect and prevent a hostile, potentially violent situation from erupting (Kaplan & Wheeler, 1989). This could be anywhere — classrooms, residential treatment centers, hospitals and welfare departments. A systematic framework developed by Kaplan & Wheeler helped in de-escalating challenging behaviors. Practicing a framework like this in a virtual environment gives teachers the opportunity to rehearse their responses to challenging behaviors.

Experts in the special education space have taken aspects from this framework that are relevant to classroom situations, in which teachers are in control of using the most appropriate strategies to de-escalate a situation. This model relevant to classroom situations has been developed by developed by Supporting Behavior 360, a third party consisting of experts in the behavior change space (section 3 gives a detailed description).

- When student is **calm** they are polite to others around them and follow instructions most of the time. Student uses limited verbal language.
- Student likes to complete tasks that they have started. When student is prevented from completing a task they can become **anxious** (as they often rely on routines and sequences with a clear start and finish to feel a sense of being okay). When feeling anxious student can become withdrawn and protective of anything they are holding or doing. They can then start self-harming (doing things like chewing their fingernails, collar and other parts of clothing, then their fingers/fist/back of hand/wrist). Student is often restless by this stage, although movements are usually small and reasonably self-contained. Student begins to be resistant to following instructions. This is often quiet or low level resistance.

- This is followed by **agitation** where they swear and use language that hurts others' feelings. Student can increase self-harm (this includes punching face/head and may include biting themselves). Student is increasing their movements up and down from their desk or the floor and walking around the room. They may start throwing items at this stage (can be very accurate if targeting). Student becomes louder with their resistance and often tells others to go away. The pitch of their voice gets higher and they may make non-verbal sounds.

- When **out of control**, student can often cause significant property damage. They may sweep things off flat surfaces (including benches, shelves or desks) as well as turn chairs and desks over and throws things randomly around a room. Student can be verbally abusive to others (including threats, name calling and swearing).

- When in **recovery** mode student can become very quiet and withdrawn. Student may seek a quiet dark area such as under furniture or a blanket. Student will often hold his/her arms and rock or stim their hands as a way of calming. Student may start to cry or show remorse at this stage as he/she starts to realise what has happened. At the end of this stage student is often ready to follow simple instructions and respond to basic questions and interactions.

This graphical representation of inter-related phases found typically in violent incidents (Kaplan & Wheeler, 1983) was adapted by Supporting Behavior 360 or SB360 (refer to section 3). Figure 2.1 represents the behavior traits associated with baseline, escalation and crisis, and the typical responses that are expected from teachers.

When confronted with challenging behavior from a student, a teacher's immediate response is critical. What are they meant to do? The natural response for a teacher is to say something to the student to bring them back to a calm state. Their choice of words is important because it helps them gain understanding of the situation a student is in at that moment. According to Morgan and Reinhart (1991, p. 169), "words can be misleading, and students will say things they do not mean." Teachers need to differentiate between truth and fiction when faced with comments from behaviorally challenged students. It is important to pay attention to how students express their feelings. While it may be difficult for teachers to remain unshaken by a student's verbal attack or tonality, that is the only way to provide a comfort zone based on trust. The key is not to deny what was said or demonstrated but to accept it (Supon & Rowe, 1998).

> Your choice of words and your language selections are critical to
> the self-esteem, the academic success, and the healthy mental and

> emotional development of your students. There is an undeniable link between the words you speak and the attitudes and outcomes students create in their lives. By selecting words and phrases intentionally; by altering your present language; by adding to or talking away from your common utterances; you can empower your students and enhance their learning.– Moorman & Weber, 1989

One way to use words is through assertive communication. Assertive communication is used during the escalation phase, late in the recovery phase, and throughout the post-crisis depression phase, and it can serve to diffuse and de-escalate feelings (Kaplan & Wheeler, 1983). Targeted practice of management skills in a safe environment with no real consequences could help young teachers avoid potential risks. Elizabeth Janeway stated: "Prediction is not the same thing as control, but it is not unrelated, either. At the least, it allows an individual to prepare for an expected event and to take defensive steps if it cannot be avoided. Moreover, though one may not be able to control the event, one can do much to control one's own responsive actions."

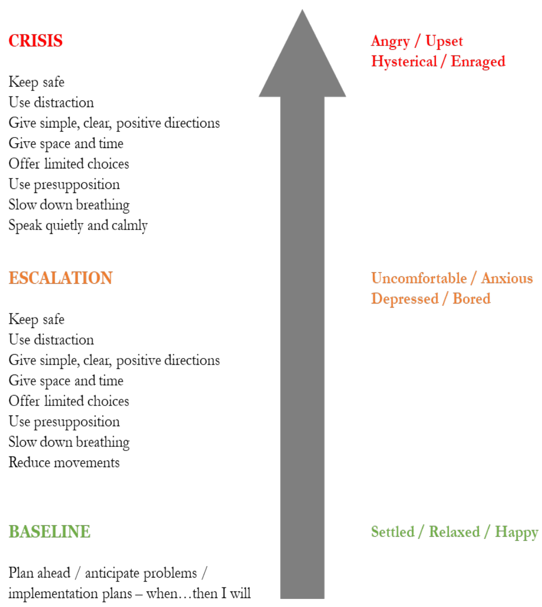

Figure 2.1: Graphical representation of baseline to crisis in a behavior cycle – On the left, teacher behaviors and on the right, status of the student

2.3 Existing virtual simulation training systems

A desktop-based virtual environment named STAR Simulator was developed aiming to simulate an urban classroom of diverse virtual students in order to provide rich experiences to the participating teachers through interactions with the virtual students (Dieker et al., 2007). The results revealed that teachers found the virtual classroom realistic enough, while the experience enhanced their knowledge and classroom management skills. Although, because this is a desktop-based application, we do not know how immersive it was.

TLE TeachLivE^{TM}, now commercialized as a company called Mursion, is a teaching and learning environment that was developed to provide an interactive learning experience for teachers to rehearse and hone their classroom skills (Barmaki & Hughes, 2015). Mursion is a technology that enables virtual simulations. In a study conducted by Hudson et al. (2019), Mursion simulations were used in the TeachLivE environment to give the avatar unique responses and behaviors as the teacher began interacting with the avatars. The participants were all pre-service teachers who interacted with virtual avatars through a 90-inch screen. The results indicated that some participant perceptions changed over time because of the Mursion experiences and that the academic program being pursued made no difference in the participants' Mursion experience. It would have been an interesting area of research to use virtual reality instead and compare the experience of pre-service and in-service teachers.

An immersive virtual reality system, Breaking Bad Behaviors, was designed by Lugrin, et al., (2016) for training classroom management skills, with a specific focus on learning to manage disruptive student behavior in face-to-face, one-to-many teaching scenarios. The core of the system is a real-time 3D virtual simulation of a classroom populated by twenty-four semi-autonomous virtual students. One of the limitations of the experiment was realizing a field of study with real teachers who possess practical experience in classroom management. This VR system was used as part of an experiment regarding potential differences between training via using a VR system and via using videos and the results revealed a significant improvement in learning outcomes using the VR approach. (Luqrirr et al., 2018).

In two of these cases, the virtual training environments are desktop-dependent applications and give just one perspective, rather than surround (immerse) users completely, as in the case of using a head mounted display. Previous research results indicate that the use of the VR environments elicit higher levels of emotional responses compared to a regular desktop computer setting (Estupiñán et al., 2014).

In our literature review, perhaps some of the very first attempts to use VR-based methodology for teacher training is that by Stravoulia et al., (2019) and researchers at the University of Buffalo. Stravoulia et al. used a VR-based approach, answering the research question – Is a VR-based learning paradigm more effective for the professional development of teachers? The results indicated that the virtual reality experience had a strong impact on the participants' negative emotional and mood states.

Researchers from University of Buffalo (UB) created a virtual reality simulation that helped teachers garner experience in dealing with difficult student behaviors [1]. The researchers compared the training method to a "flight simulator for teachers." This teaching environment was created by Richard Lamb, GSE associate professor and director of the Neuro-cognition Science Laboratory, and Elisabeth Etopio, director of UB's Teacher Education Institute. It differs from other teaching simulation platforms because in the 360-degree footage, actual student behaviors occurring within real classrooms was used, enhancing the authenticity, fluidity, and immersiveness of the experience. Although this experience would be more realistic than using virtual avatars as students, there was no scope for interaction with the students. Moreover, there was no feedback being given to the teacher who was being exposed to this environment. The research suggested that the use of virtual reality promoted learning from modeled real-life situations.

2.4 Emotions in Virtual Reality

Virtual reality is a powerful tool in human behavior research. It is important to study emotions in virtual reality because virtual environments ultimately are a re-creation of reality. However, to know if virtual training methods can be as effective as live training methods, we must know if it elicits the same or similar cognitive responses as real-world scenarios. Unfortunately, there is not much research regarding users' emotional experiences in virtual environments (Felnhofer et al., 2015).

What we intend to do in this research is see if teacher training in VR elicits the same or similar emotional response as teacher-training using live role-play. In his Differential Emotions Theory, Izard (1992) states that emotions are not only characterized by a subjective feeling, but also by a distinct physiological activity. More specifically, we are looking at stress levels and emotional arousal of participants when exposed to a 360-degree

[1] http://www.buffalo.edu/ubnow/stories/2017/06/vr-teacher-training.html

video of disruptive student behavior and during live role-play of the same situation.

Chapter 3

User Evaluation

This chapter gives an overview of the study design for each of the conditions, experiment procedure, a description of the participant pool, the hardware and software used for the study, and the measurements that were used.

3.1 Study design

The experiment intends to compare three methods of training teachers:

- Live Role-play with an actor who will play the role of a boy displaying challenging behavior
- Training using 360-degree video using a Tablet
- Training using 360-degree video in virtual reality (VR)

The participant pool consisted of pre-service and in-service teachers. In-service teachers were a mix of primary, secondary and tertiary teachers, and pre-service teachers were second and third year undergraduate students studying to become teachers. Most of the research conducted in this area has only pre-service teachers as a participant pool, so this work is unique in that it compares the physiological signals between pre-service and in-service teachers. This is a within-subject experiment conducted across three treatments — VR, Tablet and live Role-play, as depicted in Table 3.1. Table 3.2 shows the dependent and independent variables in the experiment: the methods of training are independent variables and the evaluation metrics are dependent variables.

Table 3.1: Different conditions in the experiment

Condition A	Role-play – first exposure → Role-play – second exposure
Condition B	Tablet – first exposure → Tablet – second exposure
Condition C	VR – first exposure → VR – second exposure

Table 3.2: Dependent variables: data received from measurement, independent variables: Conditions – Role-play, Tablet and VR

Measurement	R	T	V
EEG	✓	✓	✓
Heart-rate	✓	✓	✓
Voice	✓	✓	✓
Dundee Stress State Questionnaire (DSSQ)	✓	✓	✓
Igroup Presence Questionnaire (IPQ)	×	✓	×

Note: R=Role-play, T=Tablet, V=Virtual reality

Figure 3.1 represents experiment design for VR, Tablet and live Role-play conditions. This thesis compares the physiological state of the participant during two consecutive exposures to the same scenario, depending on the condition to which they are assigned. Further, we compare the first exposure in the three conditions and second exposure in the three conditions.

Pre-task questionnaire — baseline stress and confidence levels
↓
Recording of voice, heart-rate and EEG data – baseline
↓
First exposure
↓
Post-task questionnaire
↓
10-minute break
↓
Second exposure
↓
Post-task questionnaire
↓
Presence questionnaire (only in VR condition)

Figure 3.1: Design for live Role-play, Tablet and VR conditions

3.2 Pilot study

A pilot study was conducted prior to starting the main user study. The pilot had three participants – a special educator, an administration staff, and a pre-service teacher. The participant exposed to the VR and Tablet condition felt that the text prompts needed to appear for a longer duration as some people may take longer to read. We ensured that we increased the duration of the text for the main study. With respect to the live Role-play condition, the participant that trialled this condition felt that live Role-play situations are not as real and intense as a real-life scenario and are not "performed", like the experiment. Therefore for the main study, we asked our actor to "not perform" like an actor, but keep it more simple and real. We also realized that in the pre- and post-task questionnaire that participants had to complete, the responses were not recorded if the participant placed the slider between two numbers, rather than exactly on one number. We changed slider type questions to matrix type questions which solved this problem of data recording. We also realized that participants needed to use headphones in the Tablet condition for more clarity, as is the case in the VR condition. This also reduced noise when we recorded participants' voice and exported it for analysis.

3.3 Hardware and Software

The Tablet and VR conditions used a purpose-build application called Supporting Behavior 360 (SB360). SB360 has been developed by a third party consisting of experts in the behavior change space. It has been developed to incorporate real-life situations into training, to engage, improve, and empower people and organizations to proactively address responses to challenging behaviors. Since the directors of SB360 have all worked in education and behavior change, they have created scenarios for 360-degree videos based on their experiences. The application prototype was developed under the guidance of Prof Christian Jones, Department of Computer Science, University of Sunshine Coast, Australia.

In stressful situations where a student displays a behavior escalation, the nature of words teachers use to bring the student back to a calm state is extremely important. Therefore, SB360 has been designed in such a way that teachers receive text prompts while viewing the 360 video, so that they know the right words to use in times of crisis, to bring the student back to a baseline state.

While there is not much scope for interaction with the system, it has been intentionally designed that way because it is important for teachers to fully experience the behavior model on which the video is constructed. Under the assumption that any interaction or feedback while viewing the video may lead to an interruption in the level of engagement and immersiveness. This is because, often, in a real classroom, a teacher is expected to handle situations like these and may not have the option of escaping from it mid-way.

For this study, 360-degree video was recorded using a GoPro Fusion [1] with a resolution of 5.2K (5228 X 2624). The video shows an actor playing the role of a student displaying a behavior escalation. The student is in the classroom building a model at his desk. He is due to go home in the taxi van (with other students) in the next five minutes. He has completed less than half the model and is determined to complete it fully, when the teacher must intervene. The application was developed for a Samsung mobile phone. But to avoid latency while viewing, we exported the application to Unity to be viewed using a head-mounted display (HMD). The application for phone was designed such that, while the user viewed the scene, their heartrate was recorded. However, when we exported it for viewing using a HMD, we did not integrate a heartrate monitor since we used another device to record the same. For our study, we used an Oculus Rift HMD.

We used a Samsung Tablet S2 [2] for the Tablet condition in which participants were exposed to a 360-degree video. Audacity [3] was used to record the voice of participants and PRAAT software [4] was used for analysis (refer to 3.2). Medtronic's Zephyr technology [5], a wearable monitoring device, was used to record heartrate and heartrate variability of participants (refer to 3.3). A 14-channel Emotiv EPOC headset [6] was used to record brain activity, and Emotiv Pro software [7] was used for viewing and exporting raw EEG data (refer to figures 3.4, 3.5, 3.6, 3.7). All the hardware we used were non-intrusive and safe.

[1] https://gopro.com/en/nz/shop/cameras/fusion/CHDHZ-103-FW.html
[2] https://www.samsung.com/global/galaxy/galaxy-tab-s2/
[3] https://www.audacityteam.org/
[4] http://www.fon.hum.uva.nl/praat/
[5] https://www.zephyranywhere.com/
[6] https://www.emotiv.com/epoc/
[7] https://www.emotiv.com/emotivpro/

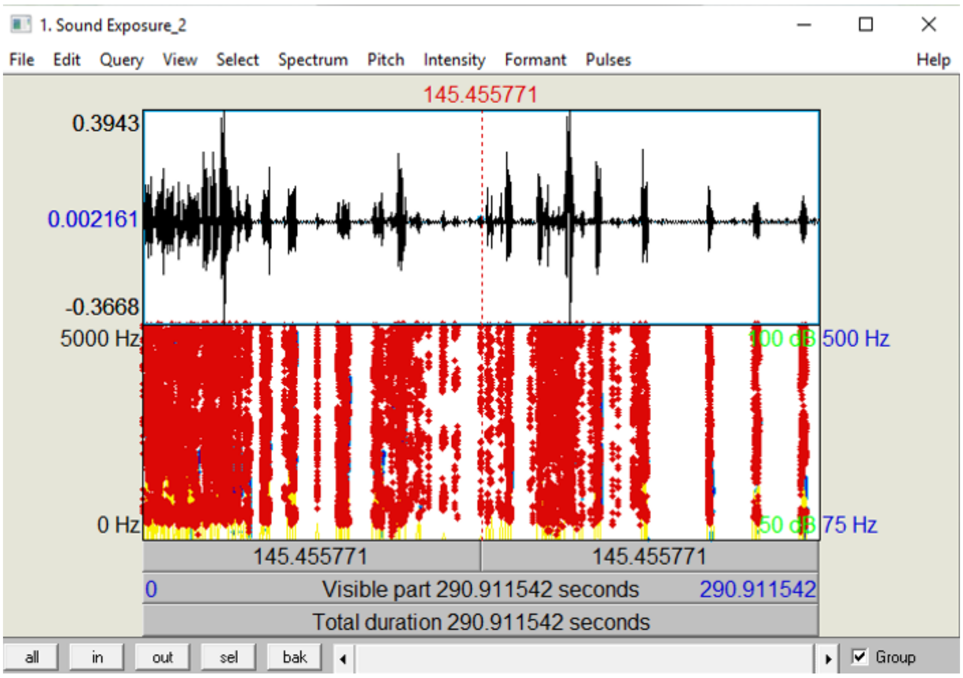

Figure 3.2: Analysis of voice in PRAAT software

Figure 3.3: Zephyr sensor for measurement of HR and HRV and the strap where it was fixed

Figure 3.4: Emotiv EPOC wireless 14-channel EEG device

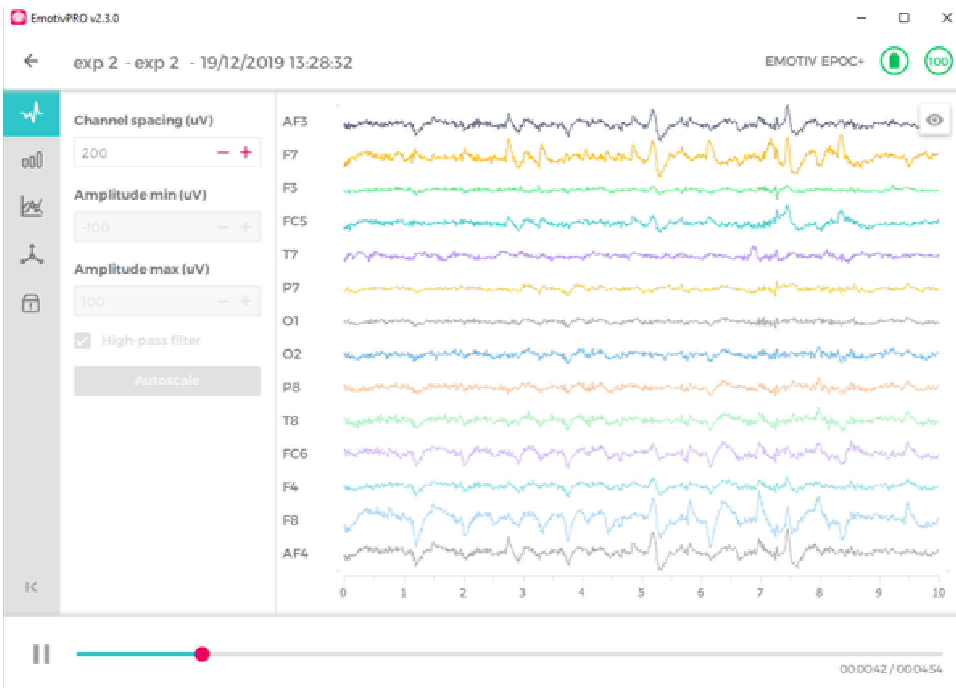

Figure 3.5: Raw EEG device as recorded in Emotiv Pro

Figure 3.6: Frequency Bands as recorded in Emotiv Pro

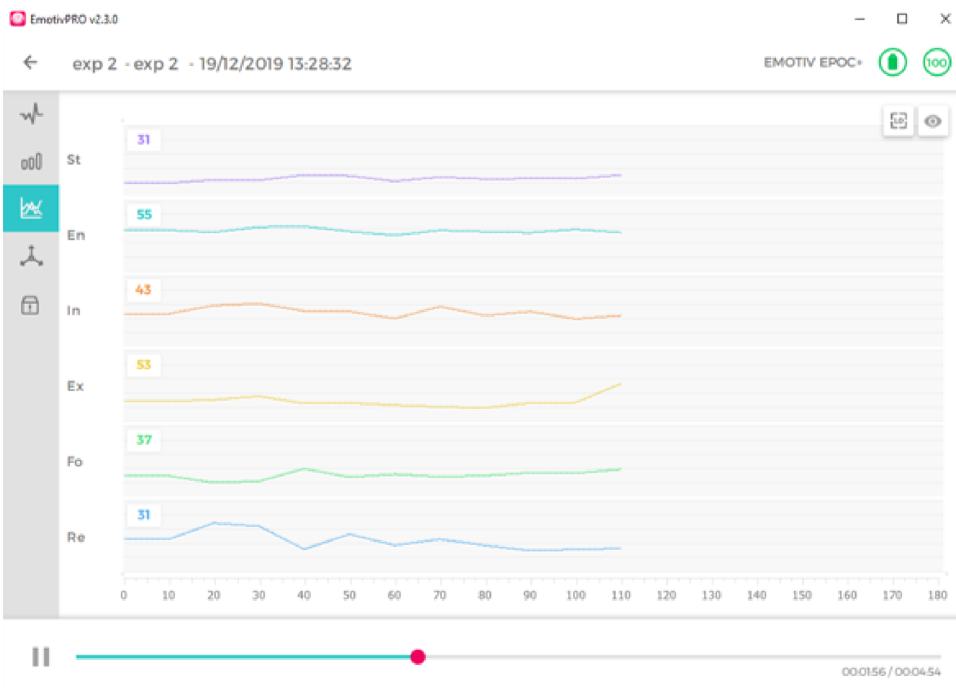

Figure 3.7: Performance Metrics as recorded in Emotiv Pro

3.4 Participants

We attempted to recruit thirty participants from both pre-service and in-service sectors (ten for each condition). University of Canterbury's College of Education staff sent out the advertisement for our study to the pre-service teachers in the department. We also posted our advertisement in some of the social network pages dedicated to teachers, as recommended by the Ministry of Education, New Zealand. We emailed the principals of some schools in Christchurch to recruit participants. In the end, we recruited only seventeen participants for the study, 6 male and 11 females. However, we could not use the data of two of the participants because we ran into some technical difficulties while recording data, and hence the data was not valid. We considered data of fifteen participants only (N=15), 5 male and 10 females (age M=34.5, SD=4.24). Some participants had no prior teaching experience (n=4), few had more than 20 years (n=2), while some had teaching experience ranging from 5-20 years (n=9). The physiological data of the participants were recorded with the approval of the Educational Research Human Ethics Committee (ERHEC)(Ref: 2019/77/ERHEC), University of Canterbury. Participants received an information sheet prior to the experiment which they had to go through before coming in. The information sheet contained all the details of the experiment including the recording of physiological data and to what they would be exposed. Participants were given the information sheet to read once again when they came in for the study. They were also given a consent form to sign before the experiment began. All participants received a gift voucher.

For the Role-play condition, we recruited an actor by posting information about the study on the University of Canterbury's social network page. We had three students interested to be an actor for the study. One of them was not comfortable playing the role of a student displaying disruptive behavior. The other two auditioned for the role and one of them was selected because he was more easily accessible. The actor was given a gift voucher every time he came in for the study.

We collected some basic demographic information from participants such as their age, gender, their years of teaching experience and if they had ever dealt with disruptive behavior from students. The demographic statistics are shown in Tables 3.3 and 3.4.

We had equal numbers of participants for all three conditions. Participants were randomly assigned conditions, except we took into consideration their years of teaching experience before assigning them a condition because we wanted equal representation of pre- and in-service teachers in all three

Table 3.3: Mean and standard deviation of participants' age across conditions

Condition	N	M_{age} (SD)
Role-play	5	39.5 (3.53)
Tablet	5	28 (2.82)
VR	5	35.5 (6.36)

Table 3.4: Previous experience with teaching and handling challenging behavior from students

	Q1			Q2		Q3			
	<1	1-10	>10	Yes	No	A	B	C	D
R	1	2	2	4	1	3	1	0	0
T	2	2	1	3	2	2	0	0	1
V	1	3	1	4	1	3	0	1	0

Note: R = Role-play, T = Tablet, V = Virtual reality; Q1 = years of teaching experience, Q2 = Have you ever experienced challenging behavior from a student?, Q3 = How did you learn to manage challenging behavior?; A = I learnt through my own experiences in classrooms; B = I have completed specialist training; C = My teacher-training prepared me for it; D = Other (Parenting)

conditions.

3.5 Procedure

Participants in the Tablet condition (Figure 3.9) and VR condition (Figure 3.8) experienced a 360-degree video of challenging behavior from a student. The video displayed text prompts that the participant used to bring the student back to a baseline situation. In the live Role-play condition (Figure 3.10), participants were made to Role-play with an actor playing the role of a student displaying challenging behavior. Since we wanted the live Role-play to be as close to the 360-degree video used for VR and Tablet conditions as possible, we made the room resemble the classroom in the video. We also provided the participant with a script that had dialogue prompts, same as the text prompts that appeared in the 360-degree video.

In all conditions, we first read out the instruction sheet to the participant. Right afterwards, participants were asked to strap the heartrate monitoring device to their chest. They were then asked to fill out a demographic questionnaire and the stress-state pre-task questionnaire before the experiment began. The reason why they were made to strap on the heartrate device first was because it gave the device enough time to capture

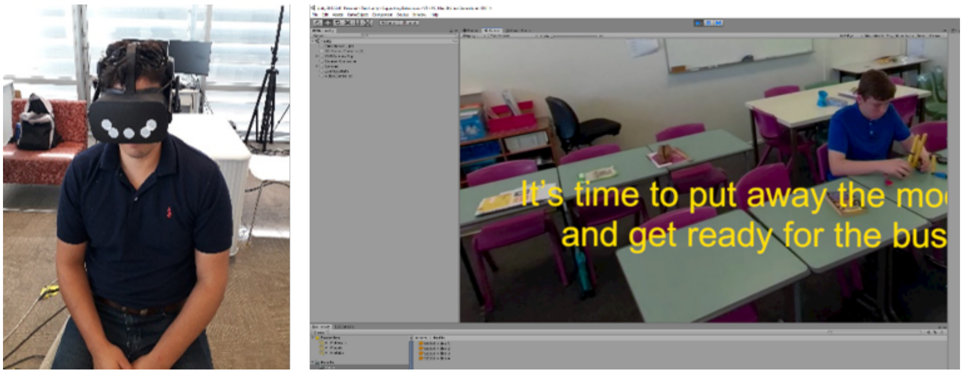

Figure 3.8: Participant in VR condition wearing Oculus Rift headset viewing the 360-degree video

Figure 3.9: Participant in Tablet condition using Samsung Tablet S2

Figure 3.10: Participant (fitted with the EEG headset) Role-playing with actor in Role-play condition

heartrate variability. We then recorded participants' baseline voice for one minute by asking them to read out a paragraph about a neutral topic. After this, the EEG device, Emotiv EPOC, was fitted to their head. In the VR condition, participants were fitted with the VR headset, in addition to the Emotiv headset. Once the first exposure was over, participants were asked to fill out the stress-state post-task questionnaire. We gave them a break for a few minutes until their physiological state was back to a resting state, and then participants went on to repeat the same task again in the second exposure. This time, they only filled out the post-task questionnaire because we intended to compare the stress state after the first and second exposures to the baseline (pre-task). Additionally, in the VR condition, participants also filled out the presence questionnaire after the second post-task questionnaire.

3.6 Measurement

This section gives an overview of the metrics we used for evaluation – voice, EEG, heartrate and heartrate variability and questionnaires.

3.6.1 Voice

Previous studies have reported that facial and vocal features are the potential indicators of human emotions like happiness, anger, fear, sorrow, disgust, and stress (Cummings & Clements, 1995; Scherer, 1986; Scherer et al., 2001., Williams & Stevens, 1972). Voice, apart from its semantic content, also carries information about the speaker's psychological and physical state. In a study conducted by Sondhi et al. (2015), significant increase in the fundamental frequency (F_0) and substantial decrease in the first two formants (F1 and F2), bands of frequency that determine the phonetic quality of a vowel, were observed under stress. An increase of over 60Hz in F_0 under stressed state when compared with neutral state has been reported (Ruiz et al., 1996).

PRAAT software is a free computer software package for speech analysis in phonetics. It was designed by Paul Boersma and David Weenink of the University of Amsterdam, and it is still being developed. It analyses and reconstructs acoustic speech signals to give the relevant data from voice: pitch, intensity, jitter and shimmer.

We recorded a baseline from the subject by making them read out a paragraph about a neutral topic, and then compared the baseline to the recording during the experiment. The recording was done using Audacity, and we imported the recording to PRAAT for analysis. We compared F_0, F1 and F2 of participants before and after the experiment. However, research indicates that F_0 can be used as a reliable indicator of stress (Sondhi et al., 2016) which is why we have used only the F_0 values for analysis.

3.6.2 EEG

The Emotiv EPOC headset consists of 14 EEG channels (AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8 and AF4) and two reference points (P3/P4 locations). Figure 3.11 shows the sensor locations and reference points. The sample rate we used was 128 samples per second with a resolution of 14 bits. Emotiv Pro software was used to record brain activity before and during the exposure. In addition to recording raw EEG data from 14 channels, the performance metrics view provides algorithm for cognitive states, out of a score of 100. The performance metrics – stress, engagement, interest, focus, relaxation and excitement, are supplied at 0.1Hz when exported. We exported the data as a CSV file and took the mean values of stress and engagement levels on a scale of 100 that were generated by the software. We also recorded Frequency Bands for alpha, beta, theta and delta rhythms. Power in most bands and electrodes is highly correlated between two states – stress and relaxation across subjects. The Emotiv Pro has a built-in 5th order sync filter, which is why we did not use a band pass filter to remove noise from the data. The alpha rhythm (8.0–12.5Hz) is associated with relaxation, while the beta rhythm (12.5 and 30Hz) is associated with an alert cognitive state, decision making and critical thinking (Ramirez & Vamvakousis, 2012). Figure 3.12 shows the valence and arousal plane for emotional states. The band power of the alpha and beta rhythm showed us how much activity is happening in each of the rhythms. Alpha band power shows a positive correlation with task demands whereas beta band powers

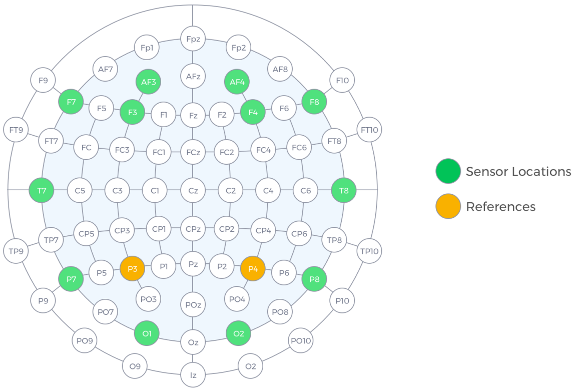

Figure 3.11: Emotiv Epoc headset: Placement of channels

shows a negative correlation with task demands (Brinkman et al., 2014). Power in the vast majority of bands and electrodes is highly correlated between two states – stress and relaxation - across subjects. EEG response to positive valence stimuli is left frontal activity while negative valence stimuli cause an increase in right activity (Giannakakis, et al., 2015).

We have used the Emotiv EPOC for exploratory purposes. The problem with Emotiv EPOC that we encountered was that it gave us conflicting and inconsistent data. Most often when heartrate increased, the stress levels in Emotiv Pro were still at a level zero. It was also a challenge to use the EEG headset along with a VR headset. Sometimes the sensors fell out and had to be reattached. It also caused discomfort to the participants. Often, Emotiv Pro showed a sensor connection of up to 60 percent although the participant had not even donned the headset. This made us rethink how much of the data we received from Emotiv EPOC is valid and correct. However, a flex cap may solve the problem of sensor-contact with the scalp. Also, on average the measurements captured by the Emotiv headset are noisy. Previous studies also show that the raw data captured data is not on the same level with laboratory-grade devices (Lyu, Y., Garti, S., Honkanan, M., 2017).

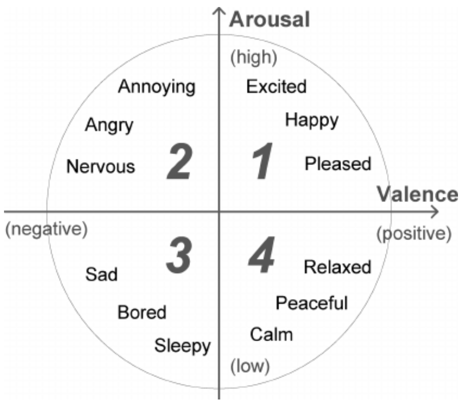

Figure 3.12: Emotional states and their position in the valence and arousal plane (Yang, Y., Chen, H, 2012)

Calculating arousal

According to Ramirez & Vamvakousis (2012), the level of arousal, i.e., how excited a person is, is determined by computing the ratio of the beta and alpha brain waves, measured in four locations in the prefrontal cortex: AF3, AF4, F3 and F4. Because of the associations beta waves have with an alert or excited state of mind and alpha waves have with a more relaxed state, the beta/alpha ratio could indicate the arousal of a person.

$$Arousal = \frac{beta_{AF3} + beta_{AF4} + beta_{F3} + beta_{F4}}{alpha_{AF3} + alpha_{AF4} + alpha_{F3} + alpha_{F4}}$$

The exported data from Emotiv gave us the power of beta low and beta high. We took the average of both to get the power of beta wave as a whole.

Calculating valence

Valence values were computed by comparing the alpha power activation levels of the left and right cortical hemispheres (Ramirez & Vamvakousis, 2012). We used the equation below for calculating valence.

$$Valence = \frac{alpha_{F4}}{beta_{F4}} - \frac{alpha_{F3}}{beta_{F3}}$$

3.6.3 Heartrate and heartrate variability

Heartrate has been found to be significantly higher after VR exposure to a stressful situation as compared to before exposure (Ding et al., 2018). For this study, Medtronic's Zephyr sensor was used. Participants wore a chest band where the sensor was attached. We recorded heartrate (HR) and heartrate variability (HRV) before and after exposure. HRV is the variability in the time interval between consecutive heartbeats in milliseconds. An increase in heartrate and decrease in HRV corresponded to increase in stress levels of the participant. For this study, we have considered only HRV because the current neurobiological evidence suggests that HRV is impacted by stress and supports its use for the objective assessment of psychological stress (Kim et al., 2017).

3.6.4 Dundee Stress State Questionnaire – DSSQ

Engagement, distress and worry levels were measured as a subjective evaluation metric, before and after the experiment. The Dundee Stress State Questionnaire or DSSQ (Matthews et al., 2002) extends mood assessments by measuring subjective states in the domains of motivation and cognition as well as affect. Due to time constraints, we used the shorter version of the questionnaire – DSSQ-3 State Questionnaire, because we wanted to measure stress and engagement levels only. Participants were asked to fill out a pre-task questionnaire for baseline and a post-task questionnaire after every exposure which was then compared to the baseline scores.

We compared engagement, distress and worry scores between the two exposures in every condition, and between the three conditions — live Role-playing, exposure to Tablet version, and exposure to VR. The questionnaire scores ranged from 0-32.

The DSSQ is based on a factor model that differentiates 11 primary state factors, which cohere around three higher-order dimensions of task engagement, distress and worry. Data also show that the DSSQ factors predict objective performance (Matthews et al., 2013).

3.6.5 Igroup Presence Questionnaire – IPQ

To understand the level of immersion during the VR scenario, the Igroup Presence Questionnaire (IPQ) was used, with principal components of analyses being Spatial Presence, Involvement and Experienced Realism. This was used only in the VR condition. IPQ, a self–report questionnaire, comprises of 14 statements rated on a seven–point scale that determine to what extend they apply to oneself (ranging from -3 = fully disagree/not at all, to +3 = fully agree/very much). The scale is filled in after being exposed to the VE and the 14 items are distributed into three sub-scales and one additional general item which assesses the general 'sense of being there' ("In the computer generated world I had a sense of 'being there'".). The first of the three sub-scales is Spatial Presence comprising five items that measure the sense of being physically and bodily present in the VE. The second sub-scale, Involvement, comprises four items which measure the attention that the subject pays to the VE and the involvement experienced. The last of the three sub-scales is Experienced Realism. This scale consists of four items which measure the subjective experienced sense of realism attributed to the VE. However, we only wanted to know whether participants felt like they were "interacting" with the person in the virtual world.

Chapter 4

Results

This section presents the results from the study across the three conditions – live role-play, tablet and VR. We compared the physiological data of participants between the three conditions and during second exposure between three conditions. To find if the difference in data was statistically significant, we conducted a one-way ANOVA. When we found a significant difference, we conducted a post-hoc test. We also compared the physiological data of participants between first and second exposures within each condition. To determine if the difference was statistically significant, we conducted an independent sample t-test.

To explore if there was any correlation between years of teaching experience and engagement levels, we conducted a Pearson product-moment correlation as a measure of strength and association that exists between the years of teaching experience and the engagement scores after first exposure. We did not find a statistical correlation ($r = -0.455$, $n = 15$, $p = 0.118$).

4.1 First exposure between the three conditions

A one-way between subjects ANOVA was conducted to compare the effect of the three conditions on heartrate (HR) during first exposure. There was a statistically significant difference found at the $p < 0.05$ level, between groups as determined by one-way ANOVA [$(F(2, 12) = 5.851$, $p = 0.017$].

Because we found a statistically significant difference, we conducted a Tukey post hoc test to compare each of our conditions to every other condition, and found a statistically significant difference ($p = 0.013$) between HR during first exposure in live Role-play and VR conditions. There was no statistically significant difference seen in the HR between tablet and role-play ($p = 0.236$) conditions and tablet and VR conditions ($p = 0.246$). This suggests that the HR during first exposure in the VR condition was significantly higher (M = 91, SD = 13.9) than role-play (M = 66.4, SD = 3.64). In other words, exposure to a student with behavior escalation in VR does have a significant effect on the HR of participants.

When we conducted an ANOVA to compare the effect on heartrate variability (HRV), we found no statistically significant difference at $p = 0.05$ confidence between groups as determined by a one-way ANOVA [$F(2, 12) = 1.537$, $p = 0.255$].

We also conducted an ANOVA to compare the effect of teacher-training on the fundamental voice frequency of participants in three conditions. There was no significant effect on the fundamental frequency of participants between the three groups as determined by one-way ANOVA [$F(2, 12) = 3.295$, $p = 0.072$].

When you look at Table 4.1, we see that the arousal levels are higher in VR than in role-play and tablet. However, when we compared the effect on arousal levels between the three conditions, we found no statistically significant difference as determined by one-way ANOVA [$F(2, 12) = 0.878$, $p = 0.441$].

Table 4.1: Mean and standard deviation of arousal levels in Hz during first exposure in all three conditions

Role-play M(SD)	Tablet M(SD)	VR M(SD)
0.7(0.52)	0.4(0.27)	0.8(0.64)

When we compared the effect on engagement scores of participants between conditions, again, we found no statistically significant difference at $p = 0.05$ significance level as determined by a one-way ANOVA [$F(2, 12) = 0.978$, $p = 0.404$]. There was also no statistically significant difference found on distress scores of participants after the first exposure as determined by one-way ANOVA [$F(2, 12) = 0.812$, $p = 0.468$]. There was no statistically difference found at $p < 0.05$ on worry scores of participants as determined by one-way ANOVA [$F(2, 12) = 1.071$, $p = 0.373$].

4.2 Second exposure between the three conditions

We conducted an ANOVA to compare the effect of teacher-training on HR in the three conditions during the second exposure. There was no statistically significant difference at $p = 0.05$ significance level, between groups as determined by one-way ANOVA [($F(2, 12) = 2.836$, $p = 0.098$]. An ANOVA conducted to compare the effect on HRV also revealed no statistically significant difference between the three conditions as determined by one-way ANOVA [$F(2, 12) = 1.947$, $p = 0.185$].

We conducted an ANOVA to compare the effect of training in all three conditions during second exposure on the fundamental frequency of participants. There was no statistically significant difference found at $p = 0.05$ significance as determined by one-way ANOVA [$F(2, 12) = 2.275$, $p = 0.145$].

When you look at table 4.2, we see that the arousal levels are higher in VR than in live role-play and tablet. However, when we compared the effect on arousal levels between the three conditions, we found no statistically significant difference as determined by one-way ANOVA [$F(2, 12) = 2.965$, $p = 0.09$].

Table 4.2: Mean and standard deviation of arousal levels in Hz during second exposure in all three conditions

Role-play M(SD)	Tablet M(SD)	VR M(SD)
0.3(0.08)	0.4(0.16)	0.4(0.04)

An ANOVA was conducted to compare the effect on engagement scores after the second exposure between conditions. We found statistically significant differences found at the $p < 0.05$ level, between groups as determined by one-way ANOVA [($F(2, 12) = 5.720$, $p = 0.018$].

A Tukey post hoc test showed statistically significant differences between engagement score during second exposure in role-play and tablet conditions (p = 0.025), and in VR and tablet conditions ($p = 0.042$). There was no statistically significant difference seen in the engagement score between role-play and VR conditions ($p = 0.952$). This suggests that the engagement score after the second exposure in role-play condition was significantly higher (M = 19.60, SD = 6.34) than tablet (M = 9.40, SD = 3.91). The engagement score in the VR condition was also significantly higher (M = 18.60, SD = 5.22) than the scores in tablet condition. To summarise, engagement scores of participants in VR and live Role-play were significantly higher than tablet after the second exposure.

As for the effect on distress scores after second exposure in all three conditions, we found no statistically significant difference as determined by one-way ANOVA [$F(2, 12) = 1.662$, $p = 0.231$]. There was also no significant

Table 4.3: Mean scores for engagement, distress and worry during pre-task, and post-task in the role-play condition

	E (M_{score})			D (M_{score})			W (M_{score})		
	Pre	(1)	(2)	Pre	(1)	(2)	Pre	(1)	(2)
R	22.0	**22.4**	9.6	10.2	**12.4**	8.2	11.2	**12.6**	9.8
T	**19.4**	18.8	14.6	12.8	**14.6**	10.6	9.8	**13.0**	10.2
V	18.0	**21.0**	18.6	12.6	**15.2**	13.0	**15.8**	14.8	11.8

Note: E = Engagement, D = Distress, W = Worry; Pre = Before exposure, (1) = After first exposure, (2) = After second exposure; R = Role-play, T = Tablet, V = Virtual reality; Scores in bold indicate the highest mean score between pre, post(1) and post(2)

effect on worry scores as determined by one-way ANOVA [$F(2, 12) = 0.555$, $p = 0.588$].

4.3 Overview of results within each condition

4.3.1 Scores from Dundee stress-state questionnaire

Participants filled out the Dundee Stress State Questionnaire before the trial and after each trial (first exposure and second exposure). The mean scores for engagement, distress, and worry during pre-task, after first and second exposures for all three conditions are given in Table 4.3.

Figure 4.1 is a visual representation of scores in the role-play condition for all participants combined.

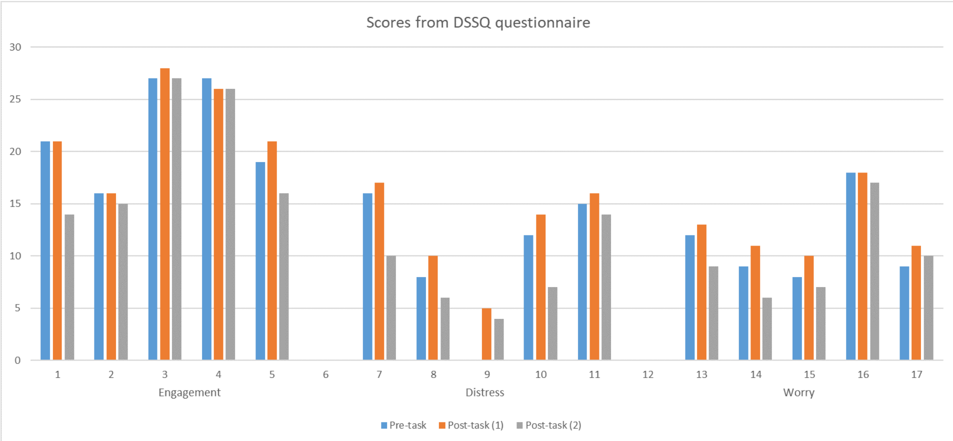

Figure 4.1: y-axis: Scores from DSSQ ranging from 0-32, x-axis: engagement, distress and worry scores of participants 1-5 during pre-task, first exposure and second exposure in live Role-play condition

Note: Post-task(1) = after first exposure, post-task(2) = after second exposure

In the role-play condition, although we see from the table that the engagement scores have increased from pre-task to first exposure but dropped from first exposure to second exposure, the difference is not statistically significant as determined by an independent sample t-test; $t(8) = 0.791$, $p = 0.452$. Similarly, although we see an increase in distress and worry scores after the first exposure and a decrease after the second exposure, the differences found at $p < 0.05$ were not statistically significant for either, $t(8) = 1.494$, $p = 0.17$ and $t(8) = 1.163$, $p = 0.27$.

Figure 4.2 is a visual representation of scores in the tablet condition for all participants combined.

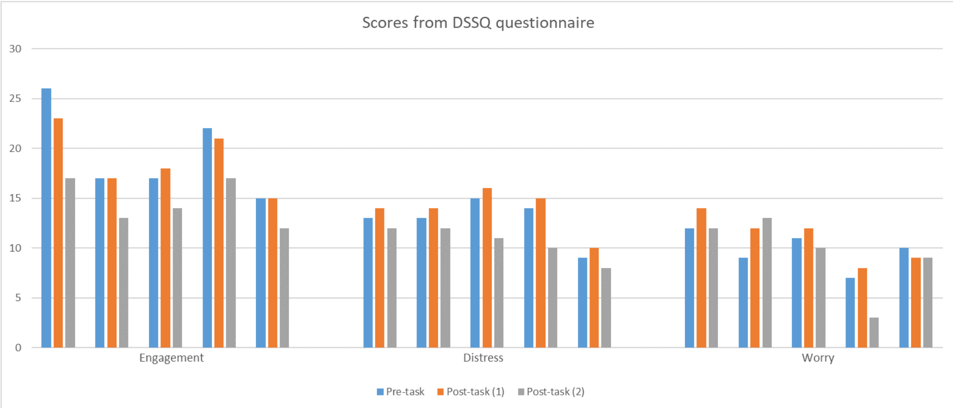

Figure 4.2: y-axis: Scores from DSSQ ranging from 0-32, x-axis: engagement, distress and worry scores of participants 1-5 during pre-task, first exposure and second exposure, in Tablet condition

Note: Post-task(1) = after first exposure, post-task(2) = after second exposure

In the tablet condition, table 4.3 indicates a decrease between pre-task and first exposure and between first exposure and second exposure. An independent-samples t-test was conducted to compare the scores between first and second exposures, and there was a significant difference in the mean scores between first exposure (M = 18.8, SD = 3.19) and second exposure (M = 14.6, SD = 2.3) conditions, $t(8) = 2.385$, $p = 0.04$. There was a significant difference in the distress scores between first exposure (M = 13.8, SD = 2.28) and second exposure (M = 10.6, SD = 1.67) conditions, $t(8) = 2.53$, $p = 0.03$. Table 4.3 shows a decrease in worry score from first to second exposure. But this is not a significant difference as determined by an independent t-test, $t(8) = 0.775$, $p = 0.46$.

Figure 4.3 is a visual representation of scores in the VR condition for all participants combined.

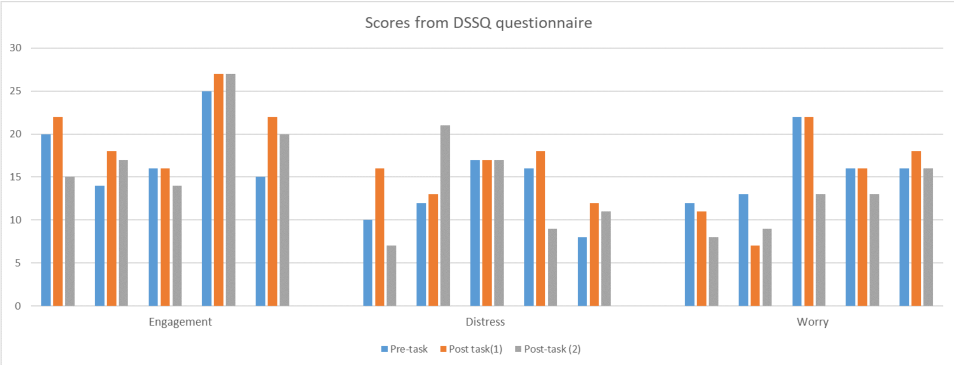

Figure 4.3: y-axis: Scores from DSSQ ranging from 0-32, x-axis: engagement, distress and worry scores of participants 1-5 during pre-task, first exposure and second exposure, in VR condition

Note: Post-task(1) = after first exposure, post-task(2) = after second exposure

For the VR condition, we can see from table 4.3 that the mean engagement scores have increased from 18 during pre-task to 21 after first exposure. This difference is not statistically significant as determined by an independent sample t-test, $t(8) = 0.797$, $p = 0.42$. There was also no significant difference in distress scores between the two exposures, $t(8) = 0.771$, $p = 0.46$. The difference in worry scores was also not significant, $t(8) = 0.996$, $p = 0.34$.

4.3.2 Fundamental frequency of voice

We recorded the baseline voice of participants before the experiment, by asking them to read a paragraph about a neutral topic for one minute. Afterwards, we recorded their voice during both of the exposures. We analyzed their voice using PRAAT software. We calculated the mean values for fundamental frequency (F_0), formants 1 and 2 (F1 and F2). However, we have only used F_0 for analysis purposes because F_0 is a reliable indicator of stress (Sondhi et al., 2016). The values for all three conditions are given in Table 4.4.

Table 4.4: Mean and standard deviation of fundamental frequency (F_0) in Hz from first and second exposures

	F_0 First exposure M(SD)	F_0 Second exposure M(SD)
R	253.3(25.21)	248.8(37.16)
T	185.4(61.85)	183.7(63.50)
V	201.0(39.48)	192.0(36.94)

Note: R = Role-play, T = Tablet, V = Virtual reality

It is visible from the table that the fundamental frequency has decreased from first exposure to second exposure in all the conditions. However, the difference is not statistically significant as determined by an independent sample t-test in the role-play condition, $t(8) = 0.67$, $p = 0.52$ and in the tablet condition, $t(8) = 0.552$, $p = 0.24$. When we compared the fundamental voice frequency in VR condition, we found a statistically significant difference between baseline (M = 197.9, SD = 22.51) and first exposure (M = 249.6, SD = 23.38); $t(8) = -3.56$, $p = 0.007$, but no significant difference between first and second exposure; $t(8) = 1.78$, $p = 0.8$.

4.3.3 HR and HRV

We also recorded the HR of participants during the two exposures. The mean HR and HRV in all three conditions are given in Table 4.5

As Table 4.5 shows, in the role-play condition, the mean HR has decreased from the first to the second exposures. The HRV has increased between the two exposures. To see if the increase in HRV was statistically significant, we conducted an independent sample t-test and note that the difference was not significant, $t(8) = -0.505$, $p = 0.62$. In the tablet condition, an increase in HR from first exposure to second exposure, and a decrease in HRV from first to second exposure can be noted. We did not find a statistically significant difference in HRV between the two exposures, $t(8) = 0.128$,

Table 4.5: Mean and standard deviation of participants' HR and HRV during both the exposures

	HR (1) M(SD)	HR (2) M(SD)	HRV (1) M(SD)	HRV (2) M(SD)
R	67.9(3.32)	67.4(1.65)	63.9(16.70)	67.1(9.66)
T	80.5(14.90)	81.4(15.32)	56.0(31.16)	54.6(27.20)
V	94.9(12.50)	85.8(11.86)	40.9(11.64)	46.0(19.33)

Note: HR (1) = heartrate during first exposure, HR (2) = heartrate during second exposure, HRV (1) = Heartrate variability during first exposure, HRV (2) = Heartrate variability during second exposure; R = Role-play, T = Tablet, V = Virtual reality

$p = 0.9$. There is a decrease in HR from first exposure to second exposure, and an increase in HRV in the VR condition. We conducted a t-test to see if the difference in HRV was statistically significant between first two exposures and found no significant difference, $t(8) = -0.399$, $p = 0.82$.

4.3.4 Engagement and stress levels from EEG data

Table 4.6 gives the mean engagement and stress scores for both the exposures. These scores were derived from the EEG recordings – performance metrics. Performance metrics data is displayed in the Emotiv application on a scaled axis from 0 to 100. The numbers represented in the table are scaled data. This means is stress shows 0.75, it translates to 75 percentage. We exported the data as a CSV file and took the average engagement and stress levels.

Table 4.6: Mean engagement and stress levels (scaled) for first and second exposure

	E (1) M(SD)	E (2) M(SD)	S (1) M(SD)	S (2) M(SD)
R	0.75(0.16)	0.64(0.18)	0.48(0.27)	0.32(0.27)
T	0.65(0.22)	0.55(0.09)	0.52(0.22)	0.33(0.12)
V	0.88(0.09)	0.75(0.24)	0.72(0.21)	0.61(0.33)

Note: E (1) = Engagement during first exposure, E (2) = Engagement during second exposure, S (1) = Stress during first exposure, S (2) = Stress during second exposure; R = Role-play, T = Tablet, V = Virtual reality

In the role-play condition, we can see a decrease in engagement and stress levels from the first exposure to the second. However, when we conducted an independent sample t-test, we found no statistically significant difference in the stress scores, $t(6) = 0.809$, $p = 0.449$, and in the engagement scores, $t(6) = 0.741$, $p = 0.405$.

Similarly in the tablet condition, there was no statistically significant difference in stress levels, $t(6) = 1.411$, $p = 0.208$, and in engagement levels, $t(6) = 0.799$, $p = 0.45$.

In the VR condition as well, although the table shows a decrease in engagement score from first exposure to second exposure, the difference is not statistically significant for stress levels, $t(6) = 0.519$, $p = 0.622$, and for engagement levels, $t(6) = 0.953$, $p = 0.67$.

Chapter 5

Discussion

5.1 Discussion of research questions and hypotheses

We state our research questions below once again and discuss them.

- Research question 1: Does virtual reality (VR) training impact the physiological state of a teacher when experiencing challenging behavior from a student as much as training using live Role-play?

  When we compared the first exposure between all three conditions, we found a significant difference in heartrate between VR and live Role-play [($F(2, 12) = 5.851$, $p = 0.017$], with overall heartrate in VR being higher (M = 91.0, SD = 13.90) than that of role-play (M = 66.4, SD = 3.64). The engagement scores of participants from the stress-state questionnaire also revealed a statistically significant difference after the second exposure [($F(2, 12) = 5.720$, $p = 0.018$], between live Role-play and Tablet, and VR and Tablet. The scores were significantly higher in VR than Tablet, and in live role-play than Tablet. However, since none of the other physiological data yielded significant results, we conclude that VR training impacted the physiological state of a teacher as much as live role-play did.

- Research question 2: Is VR as engaging as live Role-play for teacher-training?

  We found statistically significant differences between the engagement scores of participants between groups after second exposure found at the $p < 0.05$ confidence level as determined by one-way ANOVA [(F(2,12) = 5.720, $p = 0.018$]. A Tukey post-hoc test revealed that the engagement score after the second exposure in live Role-play condition was significantly higher (M = 19.60, SD = 6.34) than Tablet (M = 9.4, SD = 3.91). The engagement score in the VR condition was also significantly higher (M = 18.6, SD = 5.22) than the scores in Tablet condition. However, there was no statistically significant difference seen in the engagement score between Role-play and VR conditions ($p = 0.952$).

- Research question 3: Is there a significant difference in the physiological state of the participant between first and second exposure?

  There was no statistically significant difference seen in the physiological state of participants between first and second exposures as determined by independent sample t-tests.

We state our hypotheses below once again, and discuss them one by one.

H1 Engagement level is higher in VR as compared to Tablet and live Role-play.

There was no statistically significant difference seen in the engagement scores during first exposure when comparing the three conditions. However, during the second exposure, the engagement scores in VR were significantly higher than Tablet. The difference was not significant between VR and live Role-play. Therefore we found mixed support for H1.

H2 The physiological data show more emotional arousal during the first exposure than the second exposure.

Although we see a difference visually for all measurements, there is no statistically significant difference between the first and second exposures as determined by independent sample t-tests.

H3 The arousal levels are higher in VR than in live Role-play and Tablet.

Although the arousal levels were higher in VR than in live Role-play and Tablet, the difference was not statistically significant as determined by one-way ANOVA. Hence, we cannot conclude that VR has higher levels of emotional arousal than live Role-play and Tablet.

5.2 Observations

What we noted is that in-service teachers felt dealing with disruptive students was "just another day" for them, whereas pre-service teachers found it emotionally intense and thought it would be very helpful if they were exposed to such situations before they had to deal with real students. While most teachers do learn on the job, practicing managing student behaviors in a safe environment can possibly reduce anxiety in teachers when they must deal with real life situations. In other words, they may become more familiar with what to expect.

Although in the VR condition we did see a significant difference in the fundamental voice frequency of participants between first and second exposures, we cannot conclude that the stress levels were higher in the condition because we did not find a statistically significant result from the other physiological data.

If we had found statistically significant differences between first and second exposures, we could have concluded that training does reduce stress levels and prepares pre- and in-service teachers when they enter a real classroom. Similarly, if we had found statistically significant differences between the three conditions, we could have concluded that one method is better than the other.

During the course of the study, we asked participants for their feedback, and about their experience. The subjective feedback we received from them is summarized below for each condition.

5.2.1 Role-play condition

Among pre-service teachers, it was common to note that participants felt like they were put in a position where they needed to choose between "being a good actor" and "being able to say the correct lines as per the script." Among in-service teachers, it was common for participants to use their own improvisations, and not necessarily use the script. This perhaps comes from their experience of handling challenging behavior from students. Participants who were special educators did not feel threatened by the student-actor who displayed challenging behavior. They "get it all the time", but mainstream school teachers do not. A participant felt, "Role-play never really helped during teacher-training because you don't role-play with actual students. The reality is very different." One participant said, "I had so much fun." This often happens in role-play scenarios where participants start having too much fun in the process, and that can create some distraction from the core learning goals. Some participants had never been introduced to this method for managing challenging behaviors from students. Such participants felt that this could be a great tool to help them understand potential ways of dealing with such students without hindering learning outcomes. It was also noted that more than half of the participants did not go through role-play situations during teacher education or even if they did, live role-play still did not give them a "realistic sense of what to expect."

5.2.2 Tablet condition

One of the participants who was a pre-service teacher said, "The video was really in your face. You don't get to see such things in teacher training. It's mostly a 'tick-the-box' approach to teaching." One of the participants, who was a mainstream school teacher, started moving towards the student, although it was only a video on a Tablet. In the video, when the student reaches a stage of 'crisis', he spits at the user (camera). Some participants were taken aback by this and said, "that wasn't very nice," and "that was unexpected." Some in-service teachers mentioned that they have never role-played in their training, and to think that such behavior could happen at any instance is scary because "you are never prepared."

5.2.3 VR condition

Overall, participants felt that VR was very realistic, and that it would be an interesting tool to practice managing challenging student behavior. Since pre-service teachers are not familiar with how to handle behavior escalations from students, VR will not only give them a realistic perspective but also an idea of the language they would have to use to be in control of the situation. Whereas for in-service teachers who have had experience in handling challenging behavior from students, this would be a good tool for discussion afterwards as to what they would have done differently to handle situations like that.

5.2.4 Earthquake-related trauma in Christchurch children

More than 70 percent of participants who were in-service teachers from Christchurch said that challenging behavior from students has increased in the last few years. Participants felt that the behaviors are mostly anxiety-related, possibly originating from the trauma children faced due to the September 2010 and February 2011 earthquakes in Christchurch. Since these earthquakes, mental-health services have struggled to cope, as have many children. While mental-health services have been readily available for those affected, children often don't know when they need help. In a study involving 2500 children from 44 schools between 2006 and 2018, Liberty et al., (2016) found "high rates of post-traumatic stress symptoms" in children starting school post-earthquake, with pupils exhibiting Post-Trauma Stress

(PTS) clinical symptoms; such as being overly clingy, anxious, restless or argumentative. Rates of teacher-reported behavior problems in young children have more than doubled following the Christchurch earthquakes (Liberty et al., 2016).

For in-service teachers, exposure to 360-degree videos can be a good tool for discussion afterwards in terms of what they would have done in a situation like that, how better they could have handled it and what else they can expect from the student. Over their years of teaching and managing challenging behavior from students, experienced teachers have built a rapport with the students which has helped them form their own ways of managing such behaviors. Hence, text prompts that tell them what to do may not necessarily resonate with them. They felt, "I wouldn't have said that in this instance" or "I would have done this differently." As for pre-service teachers who are just beginning their careers as teachers, exposure to 360-degree videos in VR or Tablet could potentially help them practice handling challenging behaviors from students.

5.3 Limitations

One of the limitations of this study is that it does not take into consideration task engagement time. While in this case, each experiment lasted for about two minutes, in real classrooms scenarios, a behavior escalation may happen after 15 minutes into the class or maybe much later. Like stress, fatigue appears to be a multi-faceted construct provoking a variety of different responses (Desmond & Hancock, 2001). Stress overlaps with task-induced fatigue which is typically caused by extended work duration (Matthews et al., 2013). This study has not taken into consideration the physiological signals in a prolonged experiment where the behavior escalation happens after a certain period of teaching in a classroom.

The timing of this study was not ideal because most in-service teachers were still on school term break, and pre-service teachers had not resumed their classes. There was also a time constraint in wrapping up the study. We had only 15 participants in the end, which was not enough to achieve statistical significance.

In any 360-degree video, the key is to find the right actor to make the video as realistic as possible. While in this video, we found the right actor, as participants noted, that may not be the case in all the subsequent scenarios.

Chapter 6

Conclusions and Future Work

While this was a between-condition experiment, we exposed some participants assigned to the live role-play condition to VR as well, although we recorded data only during the condition to which they were assigned. These participants were selected based on their availability for more time than the indicated time for the overall study. The purpose was to get some qualitative feedback from them. Three participants who were in the live role-play condition were exposed to the scene in VR, and all of them felt that VR was more intense emotionally than live role-play. One participant said, "Role-play was intense because you have a great actor, and he made me nervous when he acted out like that." However, the nervousness lasted longer in VR. For ethical reasons, in the role-play condition, we could not imitate certain behaviors such as spitting and slapping that are seen in the 360-degree video. It is easier to capture situations for specialized circumstances and higher risk environments in VR than in live role-play.

Since there was no significant difference between the physiological data of the participants between VR, live Role-play and Tablet, we believe that VR could potentially be used as an alternative to live role-play as a training tool, considering all the limitations and constraints that come with role-play. Role-play, being more expensive and people-dependent, may not be the most ideal method for practicing classroom management. Moreover, in role-playing the mood state of one role-player is affected by the other role-player. VR being less people-dependent might be a good option for practicing classroom management.

We recommend that teacher-education programs introduce more new technologies like VR, as they have been shown to be viable and have a positive impact on learning. Although VR has proven to provide a much more realistic and immersive experience as compared to a 2D screen such as tablet (Ding et al., 2018), in cases where access to VR headsets may be difficult, tablets that are more accessible and easier to carry around could be used to show 360-degree videos of real students for training purposes.

Future work It would be good to focus on further research from this study with a much larger participant pool representing pre-service and in-service teachers equally, and see if there are any statistical differences in the stress state between the two subgroups. With respect to the software itself, it would be interesting to see the results when there is an option to interact with the system. For instance, designing the software such that it provides different choices of text prompts in front of the user so that the user chooses the most appropriate one for that situation might be one option. This could also provide a scoring system which would be useful for training purposes.

The results from this study are satisfying. Further research will provide more insights and observations that will help improve teacher training even more.

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Appendix

Appendix A: Information sheet

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ERHEC Ref: 2019/77/ERHEC

Teacher-training in Immersive Environments: Assessing the Most Effective Method to De-escalate Student Behaviours

Information Sheet for Pre-service and In-service Teachers

I am Aishvarya Gopalakrishnan, doing my Masters at the Human Interface Technology Lab. As part of my thesis, I am working on training teachers to handle behaviour challenges in classrooms. I intend to compare the different methods of training teachers, hypothesizing that using technology for training is a more stable method, and virtual reality (VR) in particular can help in immersive training.

My subject group requires in-service and pre-service teachers as I am evaluating the different methods of teacher-training, and want to get realistic feedback from teachers.

If you choose to take part in this study, your involvement in this project will not be for more than 1 hour. Here's a break-down of the three conditions in this experiment out of which you will be randomly assigned to only one:

1. Role-play: You will be given a scenario and will be asked to role-play with another participant.
2. 360 degree video in tablet: You will be exposed to a 360 degree video in tablet.
3. 360 degree video in VR: You will be exposed to a 360 degree video in virtual reality headset.

In any condition, there will be two exposures, with a 10-minute break between them. Before and after each condition, you will be asked to fill a questionnaire. For this study, your physiological signals – voice, heart-rate and brain waves will be recorded. You will also be asked to wear a chest band for heart-rate measurement and an EEG headset for tracking brain waves. None of these devices are intrusive, and are completely safe to use. At the end of all three conditions, you will be asked a few questions that will help me understand your cognitive state.

In the performance of the tasks and application of the procedures there are risks of motion sickness owing to the use of virtual reality headset, only in the virtual reality condition. If you have used a headset before and have experienced motion-sickness, please let us know before the experiment begins. If you get motion-sick during the experiment, you will be given a space to relax until you feel better.

Participation is voluntary and you have the right to withdraw at any stage without penalty. You may ask for your raw data to be returned to you or destroyed at any point. If you withdraw, I will remove information relating to you. However, once analysis of raw data starts on 18th January 2020, it will become increasingly difficult to remove the influence of your data on the results.

The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation: your identifying information will be anonymous as you will be given a participant code. To ensure confidentiality, all the collected data will remain within the HIT Lab and no one except myself, Rob Lindeman, my senior Supervisor, and Sungchul Jung and Misty Sato, my co-supervisors will have access to the data. The data will be kept securely stored for a minimum period of 5 years on storage systems within the University of Canterbury, and securely destroyed after that. A thesis is a public document and will be available through the UC Library.

The project is being carried out as a requirement for Masters in Human Interface Technology by Aishvarya Gopalakrishnan under the supervision of Prof Rob Lindeman, Dr Sungchul Jung and Dr Misty Sato who can be contacted at gogo@hitlabnz.org, sungchul.jung@canterbury.ac.nz, misty.sato@canterbury.ac.nz respectively. They will be pleased to discuss any concerns you may have about participation in the project.

This project has been reviewed and approved by the University of Canterbury Educational Research Human Ethics Committee.

Appendix B: Consent form

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
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Teacher-training in Immersive Environments: Assessing the Most Effective Method to De-escalate Student Behaviors

Consent Form for Pre-service and In-service Teachers

- ☐ I have been given a full explanation of this project and have had the opportunity to ask questions.
- ☐ I understand what is required of me if I agree to take part in the research.
- ☐ I understand that participation is voluntary and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.
- ☐ I understand that any information or opinions I provide will be kept confidential to the primary researcher and her supervisors, and that any published or reported results will not identify the participants. I understand that a thesis is a public document and will be available through the UC Library.
- ☐ I understand that all data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after five years.
- ☐ I understand the risks associated with taking part and how they will be managed.
- ☐ I understand that I can contact the primary researcher Aishvarya Gopalakrishnan, aishvarya.gopalakrishnan@pg.canterbury.ac.nz or senior supervisor Rob Lindeman, gogo@hitlabnz.org for further information. If I have any complaints, I can contact the Chair of the University of Canterbury Educational Research Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)
- ☐ By signing below, I agree to participate in this research project.

*Name:*____________________ *Signed:*____________________ *Date:*____________

Email address *(for report of findings, if applicable)*:

____

If you have completed the consent form, kindly return it to the researcher before the commencement of the experiment.

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Appendix C: Advertisement

We are looking for pre-service and in-service teachers to participate in a study for assessing if virtual reality (VR) is an effective tool to de-escalate disruptive student behaviors. The goal of this study is to understand the cognitive impact of training in virtual reality.

You would be asked to:

- Wear a chest strap that will track your heart-rate
- Wear an EEG headset that will track your brainwaves
- Wear a VR headset and experience a 360-degree video in VR OR experience a 360 degree video in tablet OR role-play with an actor
- Fill out some questionnaires

All recorded data will be anonymous as you will be given a participant number. The expected duration of the study is approximately 1 hour. A $25 voucher will be given at the end of the experiment. This experiment could induce cyber-sickness, as is possible with general VR experiences.

UC Educational Research Human Ethics approved this study. **Ref: 2019/77/ERHEC**

You can make a schedule via this link: https://bookwhen.com/teachertraininginvirtualreality
(Please copy and paste the link in your Chrome browser)

For more details, or to participate in the study, please contact the researcher: Aishvarya Gopalakrishnan
aishvarya.gopalakrishnan@pg.canterbury.ac.nz

Appendix D: Demographic questionnaire

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Subject #: To be filled by the researcher

Have you been employed as a teacher in a school?

Yes

No

If yes, years of teaching experience:

Did you just complete your initial teacher education program?

Yes

No

If yes, which program at University of Canterbury did you complete?

Graduate Diploma

Masters

Bachelors

Other

At what level do you teach / have you taught? – *Any classroom teaching experience is considered*
(Choose all that apply)

- Early Childhood
- Primary
- Intermediate
- Secondary

Have you ever had to deal with students displaying challenging behaviour (aggression/throwing things/verbally abusing/refusing to sit down and listen)?

- Yes
- No

If you have answered yes to the previous question, how many times have you had to deal with such students?

- Once or twice
- Quite often
- Almost daily

Do you think your training has prepared/is preparing you to handle challenging behavior from students?

- Yes, very much
- Somewhat
- Not at all

How did you learn to manage challenging behavior from students?

- I have never had to deal with students demonstrating challenging behavior
- My teacher training prepared me for it
- I learnt through my own experiences in classrooms
- I have completed specialist teacher training in this area
- Other

Age

Gender

- Male
- Female
- Non-binary
- I prefer not to declare

Appendix E: Dundee Stress State Questionnaire

For each statement, select an answer from 0 to 4, so as to indicate how accurately it describes your feelings **AT THE MOMENT.**

	0 Definitely false	1 Somewhat false	2 Neither true nor false	3 Somewhat true	4 Definitely true
I feel concerned about the impression I am making					
I feel relaxed					
The content of the task will be dull					
I am thinking about how other people might judge my peformance					
I am determined to succeed on the task					
I feel tense					
I am worried about what other people think of me					
I am thinking about how I would feel if I were told how I performed					
Generally, I feel in control of things					
I am reflecting about myself					
My attention will be directed towards the task					
I am thinking deeply about myself					
I feel energetic					
I am thinking about things that happened to me in the past					
I am thinking about how other people might perform on this task					
I am thinking about something that happened earlier today					
I expect that the task will be too difficult for me					
I will find it hard to keep my concentration on the task					
I am thinking about personal concerns and interests					
I feel confident about my performance					
I am examining my motives					
I can handle any difficulties I may encounter					
I am thinking about how I have dealt with similar tasks in the past					
I am reflecting on the reasons for doing the task					
I am motivated to try hard at the task					
I am thinking about things important to me					
I feel uneasy					
I feel tired					
I feel that I cannot deal with the situation effectively					
I feel bored					

For each statement, select an answer from 0 to 4, so as to indicate how accurately it describes your feelings **WHILE PERFORMING THE TASK**.

	0 Definitely false	1 Somewhat false	2 Neither true nor false	3 Somewhat true	4 Definitely true
I felt concerned about the impression I was making					
I felt relaxed					
The content of the task was dull					
I thought about how other people might judge my performance					
I was determined to succeed on the task					
I felt tense					
I was worried about what other people think of me					
I thought about how I would feel if I were told how I performed					
Generally, I felt in control of things					
I reflected about myself					
My attention was directed towards the task					
I thought deeply about myself					
I felt energetic					
I thought about things that happened to me in the past					
I thought about how other people might perform on this task					
I thought about something that happened earlier today					
I found the task was too difficult for me					
I found it hard to keep my concentration on the task					
I thought about personal concerns and interests					
I felt confident about my performance					
I examined my motives					
I felt like I could handle any difficulties I encountered					
I thought about how I have dealt with similar tasks in the past					
I reflected on the reasons for doing the task					
I was motivated to try hard at the task					
I thought about things important to me					
I felt uneasy					
I felt tired					
I felt that I could not deal with the situation effectively					
I felt bored					

Appendix F: Igroup Presence Questionnaire

How long did you interact with the virtual world?

What was your perspective onto the virtual world? (In the case of changing perspective, please describe the one most frequently used)

"Through the eyes of my own character," so called first-person perspective

"Behind/above my character," so called third-person perspective

Were there other real persons within the virtual environment besides yourself?

No

Yes, but I did not interact with them

Yes, and I did interact with them

Were there artificial characters (e.g. computer game opponents) within the virtual environment?

No

Yes, but I did not interact with them

Yes, and I did interact with them

Now you'll see some statements about experiences. Please indicate, whether or not each statement applies to your experience. If a question is not relevant to the virtual environment you used, just skip it. You can use the whole range of answers. There are no right or wrong answers, only your opinion counts.
You will notice that some questions are very similar to each other. This is necessary for statistical reasons . And please remember: Answer all these questions only referring to this one experience.

How aware were you of the real world surrounding while navigating in the virtual world? (i.e.sounds, room temperature, other people, etc.)?

Extremely aware			Moderately aware			Not aware at all
-3	-2	-1	0	1	2	3

How real did the virtual world seem to you?

Completely real			Moderately real			Not real at all
-3	-2	-1	0	1	2	3

I had a sense of acting in the virtual space, rather than operating something from outside

Fully disagree			Neither agree nor disagree			Fully agree
-3	-2	-1	0	1	2	3

How much did your experience in the virtual environment seem consistent with your real world experience?

Not consistent			Moderately consistent			Very consistent
-3	-2	-1	0	1	2	3

How real did the virtual world seem to you?

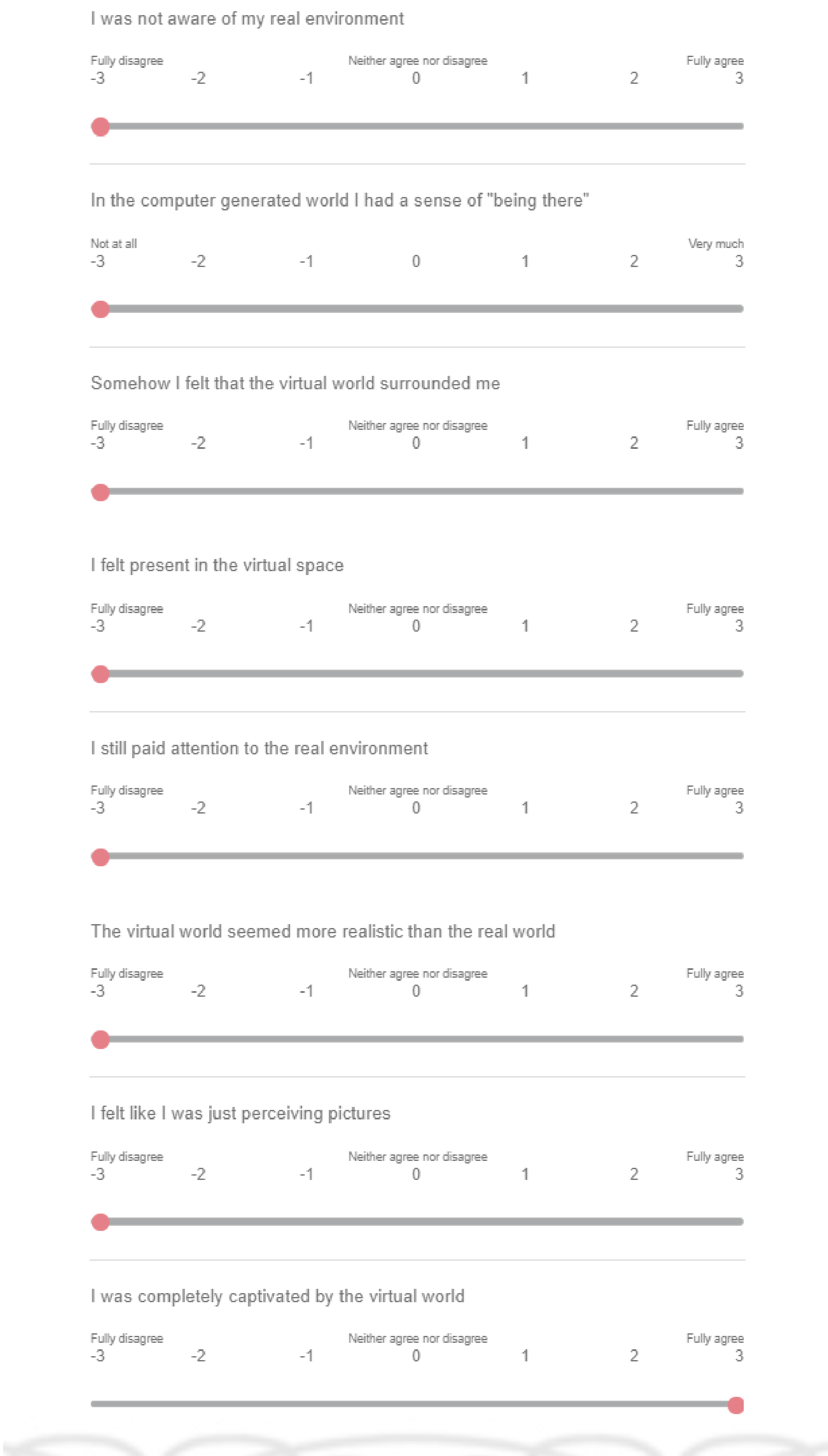
As real as an imagined world						Indistinguishable from the real world
-3	-2	-1	0	1	2	3

I did not feel present in the virtual space

Did not feel present						Felt present
-3	-2	-1	0	1	2	3

I was not aware of my real environment

Fully disagree			Neither agree nor disagree			Fully agree
-3	-2	-1	0	1	2	3



I was not aware of my real environment

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

In the computer generated world I had a sense of "being there"

Not at all -3 | -2 | -1 | 0 | 1 | 2 | Very much 3

Somehow I felt that the virtual world surrounded me

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

I felt present in the virtual space

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

I still paid attention to the real environment

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

The virtual world seemed more realistic than the real world

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

I felt like I was just perceiving pictures

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3

I was completely captivated by the virtual world

Fully disagree -3 | -2 | -1 | Neither agree nor disagree 0 | 1 | 2 | Fully agree 3